Generation of Ethyl Ether in an Ethanol Vehicle System for Cold Start Assistance

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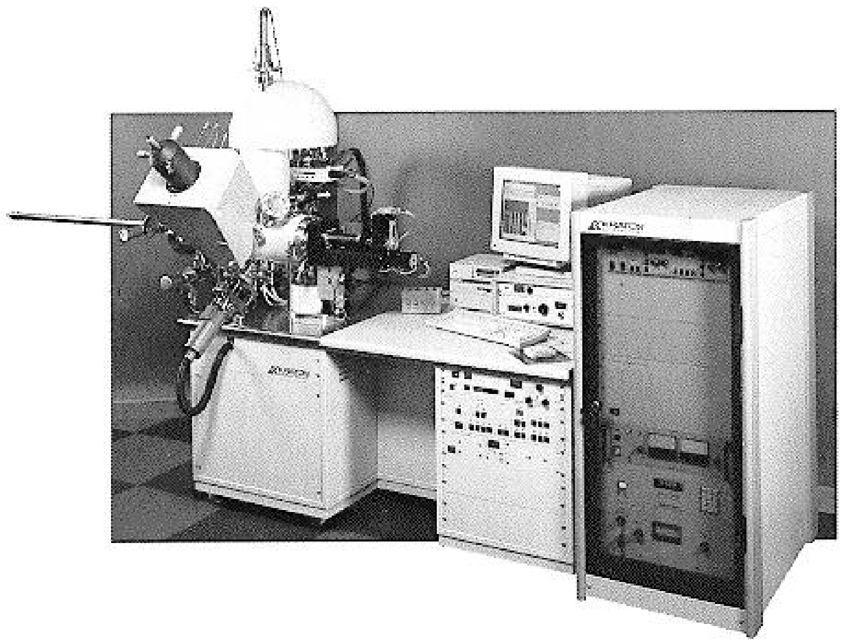

XPS instrument used to characterize APA catalysts

Subcontract Number

XCF-5-14380-01

Performance Period

11/94–1/97

NREL Subcontract Administrator

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Objective

To develop an on-board catalytic converter for converting ethanol into diethyl ether to assist in the cold-starting of ethanol fueled vehicles.

Approach

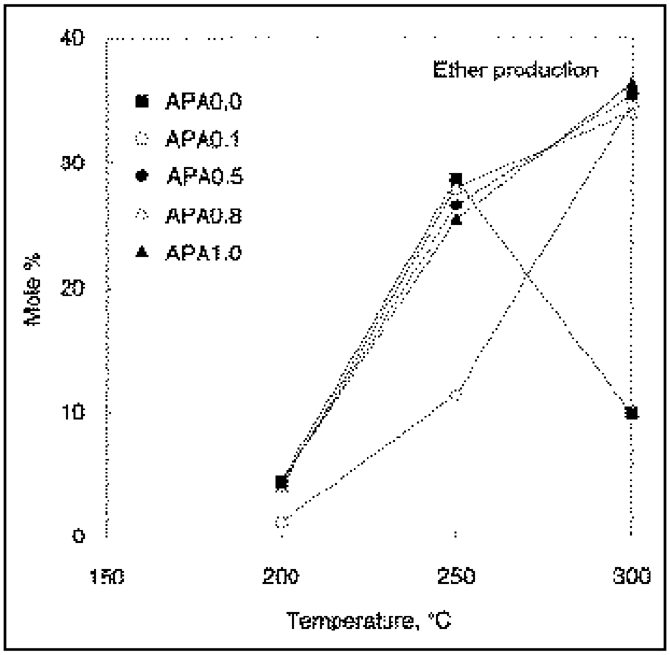
This project will consist of two phases. In Phase 1, the Colorado School of Mines (CSM) will evaluate conventional and new catalyst materials that can selectively produce ethyl ether from ethanol using a bench-scale reactor. Kinetic and thermodynamic data will be used to evaluate and predict the best process options. In Phase 2, CSM will design and fabricate an on-board prototype catalytic converter system in coordination with researchers at the Southwest Research Institute (SwRI). The prototype reactor will be installed on a Ford Taurus and its performance evaluated by SwRI.

Accomplishments

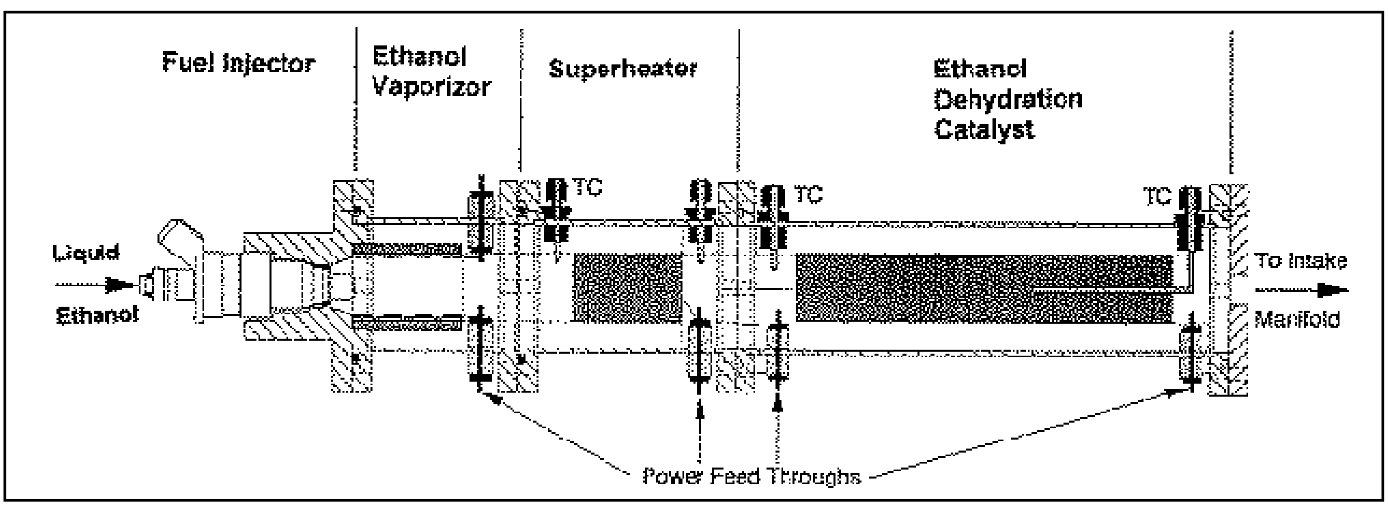
Because very little information is available on the use of ethanol-ether mixtures for cold starting a vehicle, Aspen Plus software was used to determine the vapor-liquid phase equilibria for ternary systems containing ethanol, ether, and water. The amount of ether production required to cold-start the vehicle at various temperatures was estimated.

CSM has constructed a bench-scale catalytic reactor and on-line analytical system. Several commercial and newly prepared catalyst materials were evaluated. Alumina-phosphoalumina (APA) catalysts with phosphorous-to-aluminum ratios ranging from 0.0 to 1.0 were prepared at CSM and found to have the best activity and selectivity for diethyl ether production. An activation energy, rate constant, and rate expression were obtained for selected

APA catalyst materials. The chemical and physical properties of the APA catalysts were characterized using solid-state nuclear magnetic resonance (NMR), temperature programmed desorption (TPD), total surface area analysis (BET), x-ray diffraction (XRD), and x-ray photo electron spectroscopy (XPS). The characterization and kinetic analysis was used to propose a surface mechanism for the dehydration reaction that explains the high catalyst selectivity observed. This information will be used to develop improved materials for future catalysts.



Ether production over APA catalysts



On-board catalytic converter for diethyl ether production

Future Direction

The rate constant and activation energy for the best APA catalyst material will be used to design the optimum on-board reactor system with the assistance of ASPEN PLUS software. This data will be used in the fabrication of a prototype reactor. The prototype reactor will be installed and tested on a Ford Taurus flexible fuel vehicle.

Publications

None to date.